Claims

[c1]

1.A method for performing an electromigration check for conductors with alternating current flow adjacent to conductors with direct current flow in an integrated circuit comprising:

determining resistances R_{WIRE} and a capacitance matrix **C** for the integrated circuit;

converting the capacitance matrix **C** into a thermal conductance matrix **G**;

determining temperature differences ΔT_{ni} between conductors from thermal conductances G_{thi} of the thermal conductance matrix **G**;

approximating power flow P_n into conductors with direct current flow due to adjacent conductors with alternating current flow in the integrated circuit from the temperature differences ΔT_{ni} between conductors and the thermal conductances G_{thi};

determining a power limit as a function of the maximum temperature difference ΔT_{MAX} that ensures reliability of the integrated circuit; and

performing the electromigration check by limiting power generated in the conductors with alternating current flow to less than the power limit,

wherein n, ni and thi are numerical subscripts that identify parameters as associated with conductor n, conductor n and conductor i, and a thermal characteristic of conductor I, respectively.

[c2]

2.The method of claim 1, wherein the thermal conductance matrix **G** is determined from the product of the capacitance matrix **C** and a scalar factor F and the scalar factor is given by a ratio of thermal conductivity κ to permittivity ϵ.

[c3]

3.The method of claim 1, wherein the power limit is given by the product of scalar factor F, the total capacitance C_{ntot} and the maximum temperature difference ΔT_{MAX}.

[c4]

4.The method of claim 1, wherein the I_{RMS} value is determined by the expression:

C_{load}*V_{dd}*frequency*Switching factor.

[c5]

5.The method of claim 1, wherein the thermal conductances G_{thi} are inputs for a circuit simulator that determines temperature differences between conductors ΔT_{ni} as outputs of the circuit simulator.

[c6]

6.The method of claim 1, wherein the capacitance matrix C and resistances R_{WIRE} are determined by using simulation and analysis tools that include capacitance/resistance extraction capabilities.

[c7]

7.A method for performing an electromigration check for conductors with alternating current flow adjacent to conductors with direct current flow comprising:

determining resistances R_{WIRE} and capacitances C_{ni} for conductors with alternating current flow and conductors with direct current flow;

converting the capacitances C_{ni} into thermal conductances G_{thi};

determining temperature differences ΔT_{ni} between conductors from the thermal conductances G_{thi};

approximating power flow P_n into conductors with direct current flow due to adjacent conductors with alternating current flow from the temperature differences ΔT_{ni} between conductors and thermal conductances G_{thi};

determining a power limit as a function of a maximum temperature difference ΔT_{MAX} for the conductors that ensures reliability of the conductor; and

performing the electromigration check by limiting power generated in the conductors with alternating current flow to less than the power limit,

wherein n, ni and thi are numerical subscripts that identify parameters as associated with conductor n, conductor n and conductor i, and a thermal characteristic of conductor I, respectively.

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[c8]

8.The method of claim 7, wherein the thermal conductances G_{thi} are determined from the product of the capacitances C_{ni} and a factor F and scalar factor F is given by a ratio of thermal conductivity κ to permittivity ϵ.

[c9]

9.The method of claim 7, wherein the power limit is given by the product of scalar factor F, the total capacitance C_{ntot} and the maximum temperature difference ΔT_{MAX}.

[c10]

10.The method of claim 7, wherein the I_{RMS} value is determined by the expression:

C_{load}*V_{dd}*frequency*Switching factor.

[c11]

11.The method of claim 7, wherein the thermal conductances G_{thi} are inputs for a circuit simulator that determines temperature differences between conductors ΔT_{ni} as outputs of the circuit simulator.

[c12]

12.The method of claim 7, wherein the capacitances C_{ni} and resistances R_{WIRE} are determined by using simulation and analysis tools that at least include capacitance/resistance extraction capabilities.

[c13]

13.A method for performing a check of local heating in a device comprising:

determining resistances R_{WIRE} and at least one of capacitances C_{ni} and a capacitance matrix $\mathbf{C}$ for the device;

determining thermal conductances G_{thi} from the at least one of capacitances C_{ni} and a capacitance matrix $\mathbf{C}$;

setting a maximum temperature difference ΔT_{MAX} in accordance with electromigration requirements; determining a power limit F $*C_{ntot}*\Delta T_{MAX}$ as a function of the maximum temperature difference ΔT_{MAX};

checking each interconnect conductor with an alternating current flow to determine if power generated $I_{RMS}*R_{WIRE}^2$ is less than the power limit F $*C_{ntot}*\Delta T_{MAX}$;

indicating no local heating problem with an interconnect conductor when power generated $I_{RMS}*R_{WIRE}^2$ is less than the power limit F $*C_{ntot}*\Delta T_{MAX}$;

indicating a local heating problem exist with said interconnect conductor when the power generated $I_{RMS}*R_{WIRE}^2$ is equal to or greater than power limit F $*C_{ntot}*\Delta T_{MAX}$ and taking corrective action to reduce the power generated $I_{RMS}*R_{WIRE}^2$; and

continuing to check each interconnect conductor with alternating current flow until all interconnect conductors have a value for power generated $I_{RMS}*R_{WIRE}^2$ less than the power limit F $*C_{ntot}*\Delta T_{MAX}$,

wherein n, ni and thi are numerical subscripts that identify parameters as associated with conductor n, conductor n and conductor i, and a thermal characteristic of conductor I, respectively, F is a scalar factor, and ntot is a numerical subscript identifying a total value of an associated parameter.

[c14]

14.The method of claim 13, wherein the thermal conductances G_{thi} are determined from the product of the capacitances C_{ni} and a factor F and scalar factor F is given by a ratio of thermal conductivity κ to permittivity ϵ.

[c15]

15.The method of claim 13, wherein the power limit is given by the product of scalar factor F, the total capacitance C_{ntot} and the maximum temperature difference ΔT_{MAX}.

[c16]

16.The method of claim 13, wherein the I_{RMS} value is determined by the expression:

$C_{load}*V_{dd}$*frequency*Switching factor.

[c17]

17.The method of claim 13, wherein said thermal conductances G_{thi} are inputs for a circuit simulator that determines temperature differences ΔT_{ni} as outputs of the circuit simulator.

[c18]

18.The method of claim 13, wherein the capacitances C_{ni} and resistances R_{WIRE} are determined by using simulation and analysis tools that include capacitance/resistance extraction capabilities.

[c19]

19.A computer-readable medium having a plurality of computer executable

instructions for causing a computer to perform an electromigration check for conductors with alternating current flow adjacent to conductors with direct current flow in an integrated circuit, the computer executable instructions comprising:

instructions for determining resistances R_{WIRE} and a capacitance matrix **C** for the integrated circuit;

instructions for converting the capacitance matrix **C** into a thermal conductance matrix **G**;

instructions for determining temperature differences ΔT_{ni} between conductors from thermal conductances G_{thi} of the thermal conductance matrix **G**;

instructions for approximating power flow $\mathbf{P}_n$ into conductors with direct current flow due to adjacent conductors with alternating current flow in the integrated circuit from the temperature differences ΔT_{ni} between conductors and the thermal conductances G_{thi};

instructions for determining a power limit as a function of the maximum temperature difference ΔT_{MAX} that ensures reliability of the integrated circuit; and

instructions for perfoming the electromigration check by limiting power generated in the conductors with alternating current flow to less than the power limit,

wherein n, ni and thi are numerical subscripts that identify parameters as associated with conductor n, conductor n and conductor i, and a thermal

characteristic of conductor I, respectively, F is a scalar factor, and ntot is a numerical subscript identifying a total value of an associated parameter.

[c20]

20.The computer readable medium of claim 19, wherein the thermal conductance matrix **G** is determined from the product of the capacitance matrix **C** and a scalar factor F and the scalar factor is given by a ratio of thermal conductivity κ to permittivity ϵ.

[c21]

21.The computer readable medium of claim 19, wherein the power limit is given by the product of scalar factor F, the total capacitance C_{ntot} and the maximum temperature difference $\Delta T_{\underline{MAX}}$.

[c22]

22.The computer readable medium of claim19, wherein the I_{RMS} value is determined by the expression:

C_{load}*V_{dd}*frequency*Switching factor.

[c23]

23.The computer readable medium of claim 19, wherein the thermal conductances $\mathbf{G}_{thi}$ are inputs for a circuit simulator that determines temperature differences between conductors ΔT_{ni} as outputs of the circuit simulator.